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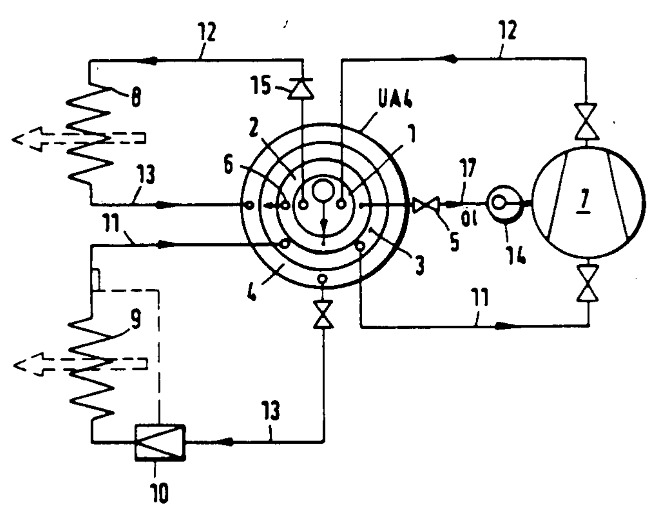
(54) Liquid/gas separating apparatus for refrigeration installations

(57) Liquid/gas separating apparatus for use in a compression-type refrigeration system comprises at least two concentrically arranged chambers (1,2,3,4) formed as a single unit (UA4) different ones of the chambers being used for different ones of the functions to separate oil from the compressed gas stream, to degas this return oil, to separate liquid from the intake gas stream and to collect the condensed refrigerant liquid. The close proximity of the different chambers improves functioning, particularly as a result of heat transfer from chamber to chamber.

Fig.1



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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Fig.1

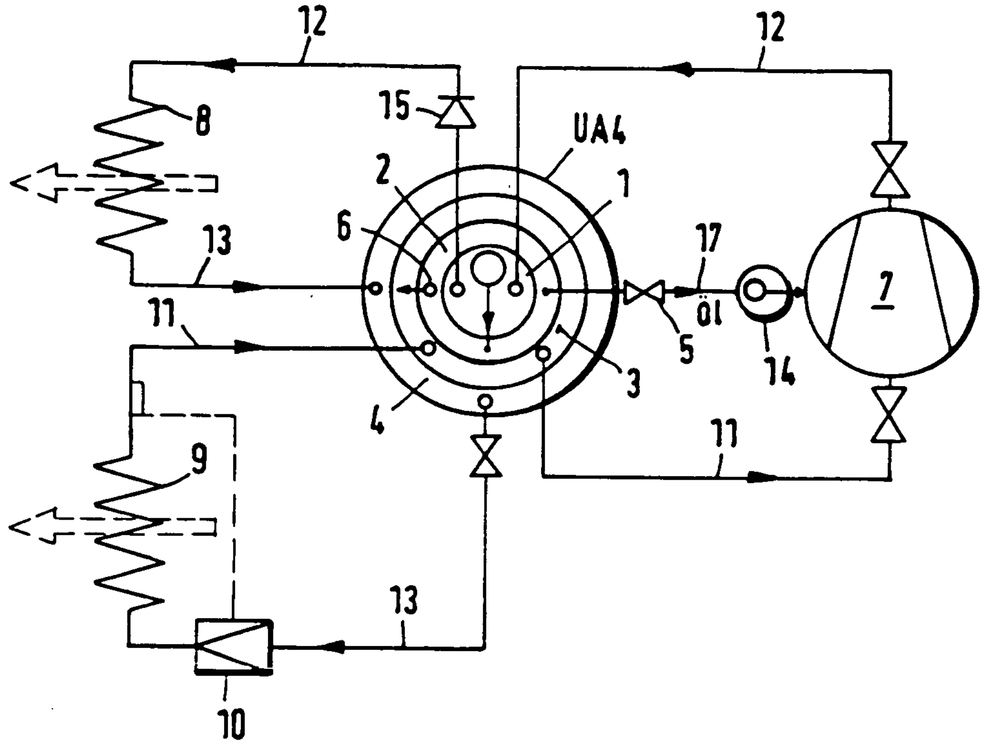
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Fig.2

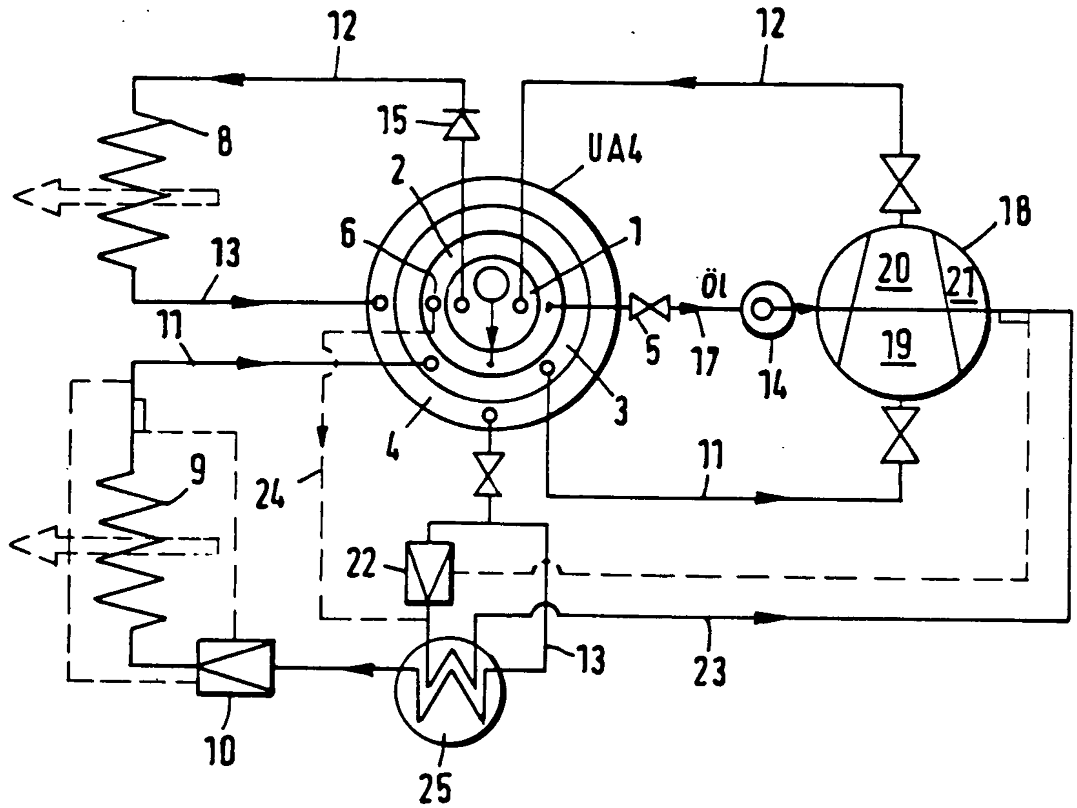
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Fig.3

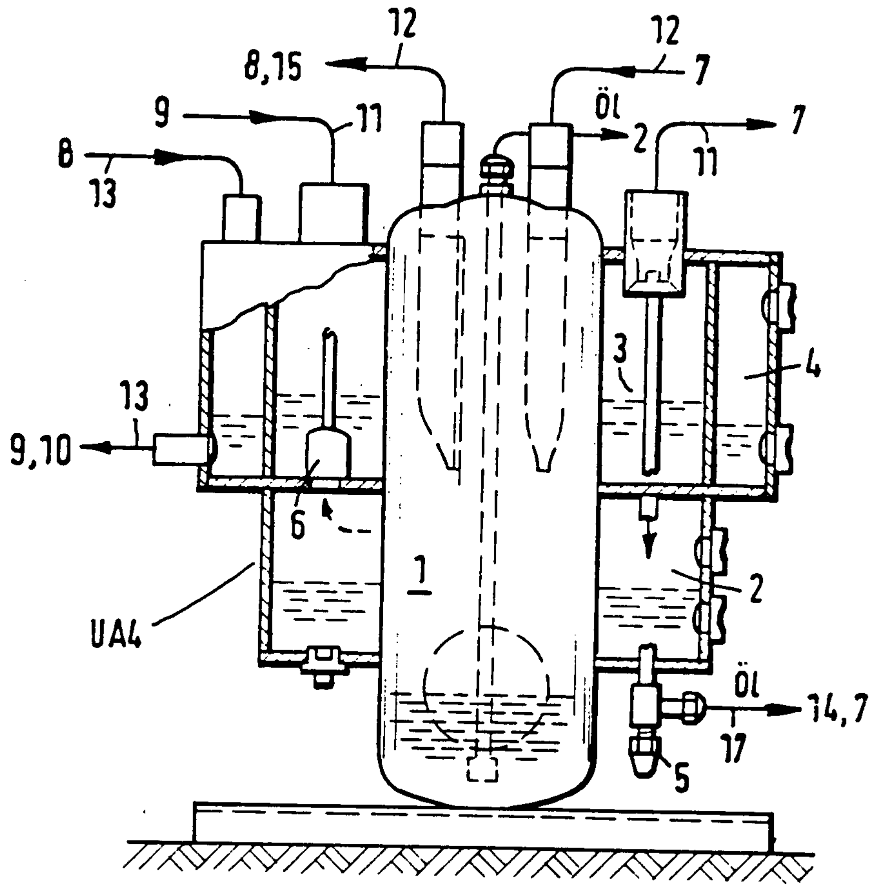
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Fig.4

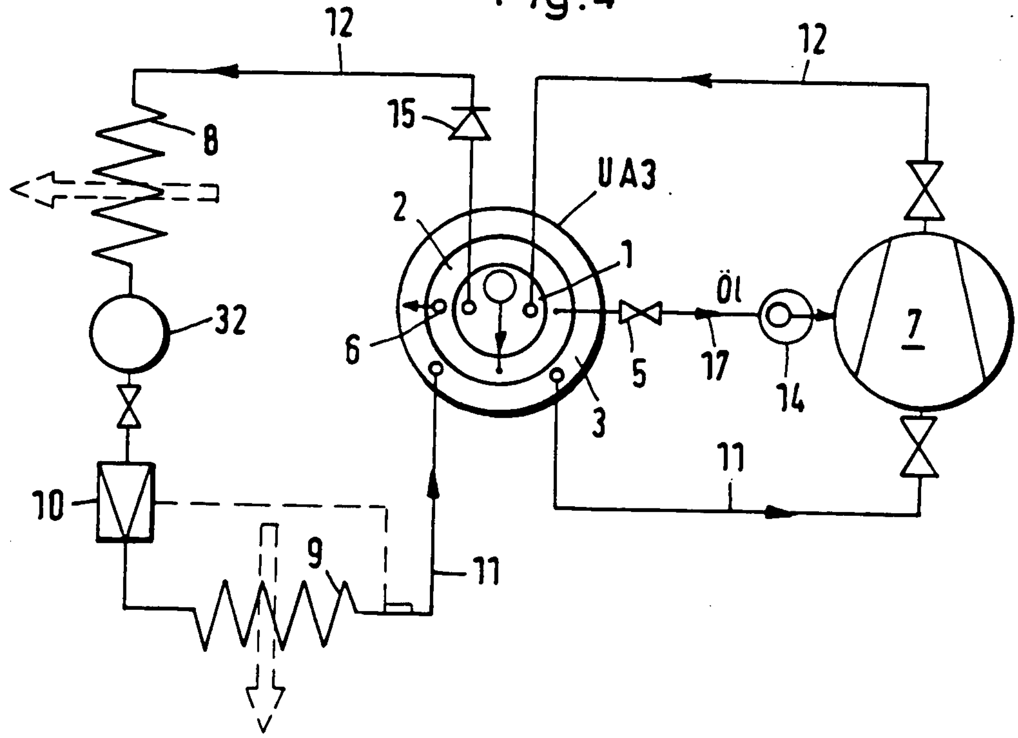
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Fig.5

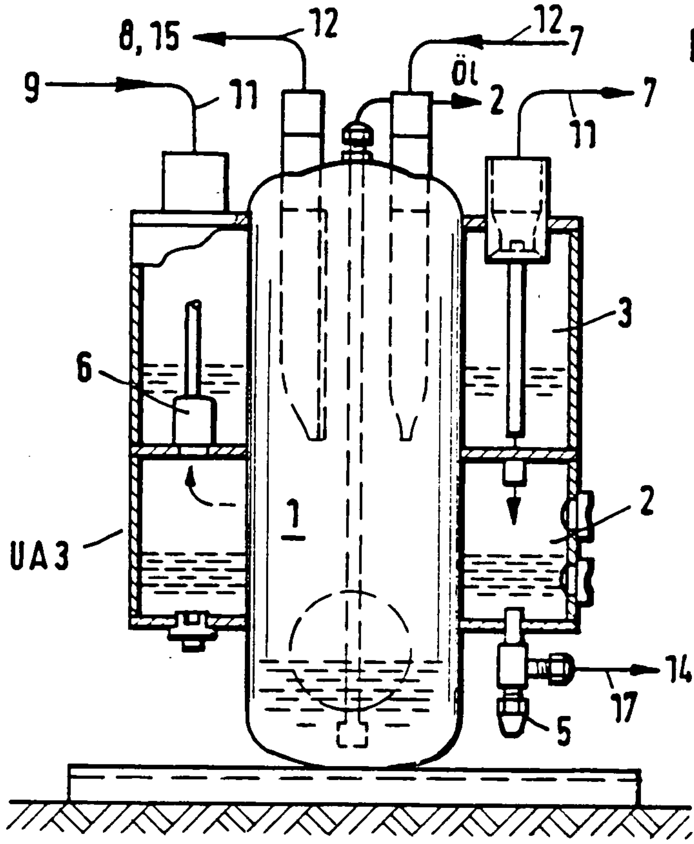

Fig.6

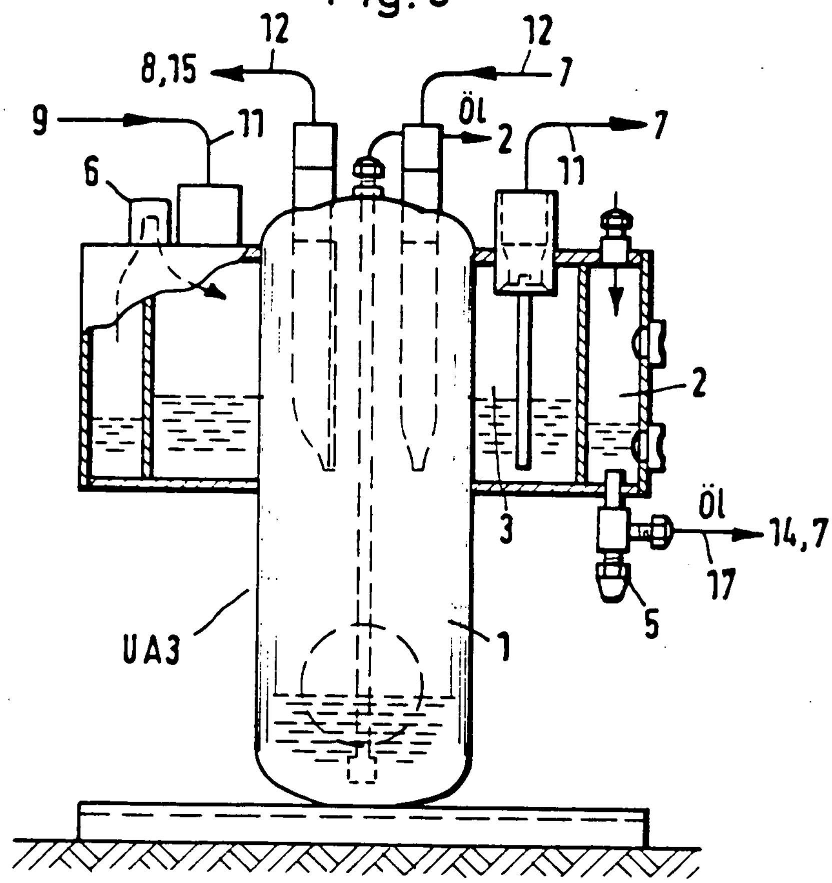

Fig. 7

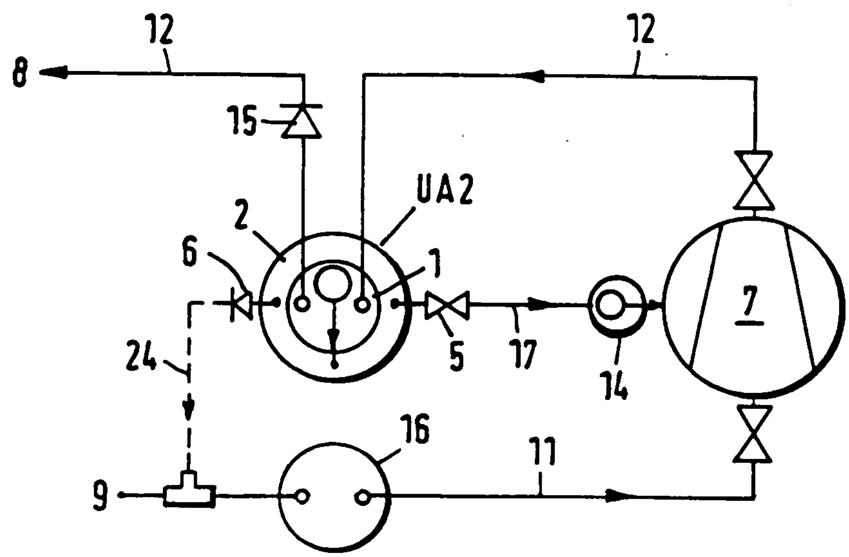
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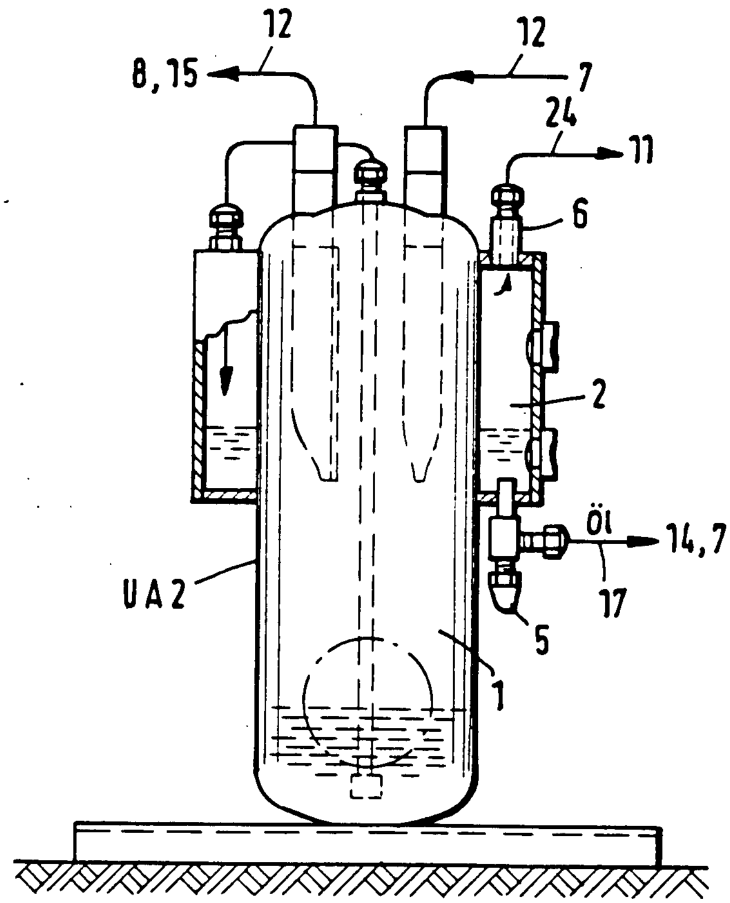
Fig. 8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SPECIFICATION

Liquid/gas separating apparatus for refrigeration installations

The invention relates to liquid/gas separating apparatus for compression-type refrigeration installations.

It is known to use separate oil traps, oil degassing/oil collecting vessels, liquid traps and liquid collectors in refrigeration installations.

It is an object of the invention to construct a liquid/gas separating apparatus of the initially mentioned type in such a way that it is compact and economical to operate while providing for correct and reliable oil return with protection against hydraulic surges.

According to the invention there is provided liquid/gas separating apparatus for compression-type refrigeration installations which comprises at least two concentrically arranged chambers provided in a single apparatus, such chambers being constructed each to carry out a different one of the operating functions to separate oil from the compressed gas stream, to degas the return oil and to separate liquid from the intake gas stream. Preferred embodiments of the invention have three and four operating chambers.

In an apparatus with two operating chambers only the operating functions "separate oil from the compressed gas stream" and "degas this return oil" or, in place of the latter, "separate liquid from the intake gas stream" can take place, or the operating functions "degas the oil" and "separate the liquid" can be combined. These operating functions can also be provided in various combinations, in apparatuses with three and four operating chambers, the additional function being "collect the condenser refrigerant liquid".

The operating chambers separate the circulating media from one another, but preferably are so arranged relative to one another that they mutually influence one another in an advantageous manner. The relative arrangement of the operating chambers is decided by economic, constructional, functional and thermodynamic considerations, but the design with operating chambers arranged concentrically next to and above one another represents an optimum.

In the text which follows, the abbreviations shown below are used for the individual functions:

Separate the oil from the compressed gas stream	= OS
Degas this return oil	= D
Separate liquid from the intake gas stream	= SL
Collect the condensed refrigerant liquid	= CL

The multiple supply functions of the apparatus with four operating chambers are as follows:

1. Effective, almost complete separation of the refrigerator oil from the compressed gas stream of the compressed gas line, in the OS operating chamber, by appropriate fitments (screens or baffles) and proper size of volume and appropriate oil return (float mechanism) into the D operating chamber, the nature and position of the feed also being determined by the particular degassing task (gas space, distance from the oil level and from the degassing line).

2. Effective degassing of the return oil in the D operating chamber by pressure release via a degassing device (for example a degassing valve with a downstream vapour dome and build-up zone for continuous degassing action), and adequate oil supply. Cooling of the fed-in return oil in the supply line (constructed as a smooth pipe, ribbed pipe or pipe coil) in the region of the SL operating chamber, also by virtue of its cooling action on the stock of oil in the D operating chamber, given an appropriate constructional arrangement. Constant-pressure return of the degassed and cooled oil to the crank case of the refrigeration compressor via an oil-level regulator (float mechanism) provided on the crank case.

The total, closed sequence of oil separation, float-regulated oil return, degassing and cooling under thermally advantageous influence, with short, advantageous flow transistions within the apparatus is advantageous.

It constitutes an optimum both in constructional and functional respects, since, in the preferred embodiments of the apparatus, the oil is separated off with high efficiency (there is a saving of energy since only the small residual amount of oil abstracts energy from the refrigerant medium and is transported through the refrigeration circuit and adversely influences the efficiency of the refrigeration installation, and furthermore movement of oil to an undesired location, and secondary damage resulting therefrom, are avoided), and the amount of oil collected is returned in a mechanically regulated (reliable) manner, and is thereafter immediately degassed (hence avoiding oil frothing in the refrigeration compressor, and secondary damage) and is at the same time cooled (thereby avoiding unnecessary heating-up of the compressor bearings).

Refrigerator oil returned from the pressed gas streams usually contains dissolved refrigerant. This often results in damage to the refrigeration compressor on starting up and in operation (hydraulic knocks, valve damage and even valve plate fracture, damage to bearings and the like).

To prevent this occurring, electrical heaters for the crank case, or pump-off circuits, are usually provided, in order to expel or pump off the refrigerant dissolved in the oil. This consumes additional energy and in some cases entails greater expenditure on apparatus.

The hot refrigerator oil separated from the compressed gas stream in the OS operating chamber, for example by means of screens and baffle plates ($t_{OS}>t_{D}$) is passed, for example via a mechanical float valve,

to the D operating chamber. As a result of the effect occurring in the D chamber and the heat flux from the OS chamber, given an appropriate constructional arrangement of the chambers and design of the heat-exchange surface, the following thermodynamic effects are achieved:

Degassing by pressure release (pD<pOS), substantially assisted by thermal expulsion of gas (qOS→qD).

As a result of the thermal effect of the SL chamber ($t_{SL}<t_D$), but also by appropriate passage in pipes through the SL chamber, or by passing into an additional chamber connected to the atmosphere ($t_R<t_D$), a thermodynamic, important interaction is additionally achieved, since the return oil is cooled in an advantageous manner whilst the liquid separated off in the SL operating chamber, and the intake gas flowing through this chamber, are heated in an advantageous manner.

This presupposes appropriate constructional arrangement of the operating chambers, of the internal fitments and of the use of, for example, heat-conducting, but also heat-insulating surface zones, and also, for example, a modified allocation of the chambers, of the internal fitments and of the connections (for example, in the SL chamber the heating of the intake gas is controlled through a different position of the connections).

Multiple protective effects of the apparatus with four operating chambers:

1. Effective, reliable separating-off the liquid (refrigerant, residual oil or mixtures thereof) which has migrated to the intake gas side or has been entrained by the intake gas stream, and, on the other hand, continuous return of this liquid (in the form of a mist and hence affording protection, via a Ventiru jet with intake tubes) from the SL operating chamber, with a volume appropriate to the system, to the refrigeration compressor via its intake gas stream. As a result, the following types of damage to the compressor are efficiently avoided by the use of this system: seizing-up of the bearings due to shrinkage (supercooling), hydraulic knocks (hammering of the pistons, breakage of the operating valves, pistons, eccentrics and crankshafts, and tearing of gaskets), and interference with the lubricating oil supply (oil frothing, and damage to the bearings). The volume appropriate to the system, as a function of the refrigeration capacity and size of installation, is achieved, for larger collected amounts of separated-off liquid, by parallel connection of a container, of appropriate size, to the SL operating chamber via communicating pipes.

2. Efficient supercooling ($t_s<t$) of the refrigeration liquid, issuing from the condenser via the liquid line, in the CL operating chamber, especially as a result of the refrigerating action of the SL operation chamber, given an appropriate relative arrangement of the two operating chambers. Supercooling has the following advantages and protective effects in respect of the operation of the installation:

a. No premature evaporation (with the possible consequences of cavitations and of hammering of the expansion valve), under normal pressure loss in the liquid line

b) No premature evaporation in the case of a relatively long liquid line

c) Increase in refrigeration capacity (greater difference in enthalpy).

In addition to these protective effects and the improvement in efficiency of the refrigeration installation, the positive thermodynamic interaction of the two operating chambers deserves mention. As a result of the heat flux from the CL operating chamber to the SL operating chamber, given an appropriate constructional arrangement, not only is the liquid in the CL operating chamber cooled but the intake gas stream passed through the SL operating chamber, and the liquid separated off (refrigerant, residual oil and mixtures thereof) is heated in an advantageous manner (tFL. toh>to).

Advantages: low viscosity of the oil refrigerant mixture drawn in from the SL operating chamber, even at low temperature operation, and, furthermore, no excessively low intake gas entry temperature into the refrigerant compressor; the degree of heating of the intake gas stream in the SL operating chamber can be influenced through the spacing, and the position, of the entry and exit nozzles, which is also a feature of this invention. The volume appropriate to the system, as a function of the refrigeration capacity and installation size, is achieved, for larger amounts of liquid taken up by parallel connection of a container of appropriate size to the CL operating chamber via communicating pipes.

The apparatus can correspondingly be constructed with two and three operating chambers, in which case two or three of the function sequences described above are allotted to the operating chambers. Different combinations of functions are possible.

The apparatus is accordingly suitable for universal supply and protection use in refrigeration installations in respect of reliable oil return, appropriate to the system, and equally effective protection against hydraulic knocks, and is in particular suitable for compression refrigeration installations, whether they are in the form of single-circuit or multi-circuit design, regardless of the number of stages and whether they are put in cascade arrangement.

The design and connection structure of the apparatus permits simple connection to, or simple accommodation of, control equipment and or signalling equipment in the relevant operating chambers, in order to indicate or regulate liquid levels.

The invention will be further described, by way of example, with reference to the accompanyng drawings wherein:

Figure 1 shows a flow diagram in respect of a single-circuit refrigeration installation embodying the invention and having a one-stage compressor;

Figure 2 shows a flow diagram in respect of a single-circuit refrigeration installation embodying the invention and having a two-stage compressor;

Figure 3 shows in part vertical section an embodiment of four chamber separating apparatus as used in the installation of Figure 1;

Figure 4 shows a flow diagram in respect of a single-circuit refrigeration installation with a one stage compressor and including a three chamber separating apparatus;

Figure 5 shows in part-vertical section an embodiment of three chamber separating apparatus as used in the installation of Figure 4;

Figure 6 is a view similar to Figure 5 showing a modified embodiment of three chamber separating apparatus.

Figure 7 shows a flow diagram of a single-circuit refrigeration installation with a one-stage compressor and having a two chamber separating apparatus; and

Figure 8 shows in vertical part-section an embodiment of two chamber separating apparatus as used in the installation of Figure 7.

In the various figures, 1 indicates an operating chamber for separating oil out of a compressed gas stream, 2 indicates an operating chamber for the degassing of this return oil, 3 indicates an operating chamber for separating liquid out of the intake gas stream and 4 indicates an operating chamber for collection of the condenser refrigerant liquid. It is, of course, possible for the individual operating chambers to be arranged in various ways relative to one another.

Figure 1 shows the flow chart of a single-circuit refrigeration installation with a one-stage compressor (7) and a UA4 separating apparatus having four chambers for carrying out four different separating functions. The following interactions between the operating chambers OS (1), D (2), SL (3) and CL (4) result:

The refrigerant stream, produced by the refrigeration compressor (7), of the refrigeration circuit first enters the OS operating chamber (1) as a compressed gas stream (V) via the compressed gas line (12). In this chamber, the compressor oil entrained by the compressed gas stream is separated off virtually completely and is conveyed, at the same rate as it is separated from the gas, into the D operating chamber (2) under the pressure (p) of the compressed gas.

Here, the compressed gas dissolved in the oil is expanded at a lower pressure ($(po+\triangle p) < p$) and is conducted via a degassing valve (6) to the SL operating chamber (3). The oil, which has been degassed and stocked in the D operating chamber (2) is cooled as a result of the cooling action of the SL operating chamber (3) ($t_{SL}<t_D$).

The compressed gas stream ($\dot{V}$) passes from the OS operating chamber (1) via a downstream non-return valve (15) in the compressed gas line (12), to the condenser (8). The refrigerant liquid which issues therefrom passes via the liquid line (13) into the CL operating chamber (4), where it is supercooled by the cooling action of the SL operating chamber (3) and of the atmosphere.

From the CL operating chamber (4) the supercooled refrigerant fluid flows through the liquid line (13) to the expansion valve (10), where it is expanded to the evaporation pressure (po) and is injected into the vaporiser (9).

The vaporised refrigerant enters the SL operating chamber (3) as an intake gas stream ($\dot{V}o$) via the intake gas line (11). In this chamber, the liquids (refrigerant, residual oil or mixtures thereof) which have been entrained by the intake gas stream or have migrated from the liquid side are separated off efficiently and collected. Together with the issuing intake gas stream, these liquids are continuously drawn off, in an appropriately protected form, by the refrigeration compressor (7) via the intake gas line (11).

The degassed and cooled return oil stocked in the D operating chamber (2) passes, under a constant pressure difference ($\triangle p$), via an exit shut-off valve (5) and oil return line (17), and via an oil level regulator (14), into the crank case of the refrigeration compressor (7).

Figure 2 shows a flow chart of a single-circuit refrigeration installation with two-stage compressor (18), liquid supercooler (25) and four chamber separating apparatus UA4. In this installation, an interaction between the operating chambers OS (1), D (2), SL (3) and CL (4) analogous to that described in relation to Figure 1 results; the following effects, associated with the two stage operation, are to be noted: the compressed gas stream ($\dot{V}$) passes from the high pressure stage (20) into the refrigeration circuit, and the intake gas stream ($\dot{V}o$) passes via the line 11 to the low pressure stage (19) of the two-stage refrigeration compressor (18). The pressure prevailing in the crank case is virtually middle pressure (pm), since the crank case is connected to the middle pressure zone (21). In the D operating chamber (2) this requires a pressure ($(pm+\triangle p)<p$) greater than the middle pressure (pm). This is achieved by degassing in the direction of the middle pressure zone (21). For this purpose the degassing line (24) is connected to the liquid injection line (23) between the expansion valve (22) for the intermediate injection, and the liquid supercooler (25).

Figure 3 shows an illustrative embodiment of a four chamber, four function, separating apparatus UA4 with an operating chamber system (OS (1), D (2), SL (3) and CL (4)) and interactions as described for Figure 1.

Figure 4 shows the flow chart of a single-circuit refrigeration installation with one-stage compressor (7) and three chamber separating apparatus UA3, whose three operating chambers are based on the functions OS (1), D (2) and SL (3). This accordingly results in the following interactions:

The refrigerant stream, generated by the refrigeration compressor (7), of the refrigeration circuit first enters the OS operating chamber (1) as a compressed gas stream ($\dot{V}$) via the compressed gas line (12). In the chamber (1), the compressor oil entrained by the compressed gas stream is separated off virtually completely and conveyed, at the same rate as that at which it is separated from the gas stream, into the D operating chamber (2) under compressed gas pressure (p). In this chamber, the compressed gas dissolved in the oil is expanded at a lower pressure ($(po+\triangle p) <p$) and led away to the SL operating chamber (3) via a degassing valve (6). The oil degassed and stocked in the D operating chamber (2) is cooled by the cooling

action of the SL operating chamber (3) (tSL<tD).

The compressed gas stream ($\dot{V}$) passes from the OS operating chamber (1), via a downstream non-return valve (15) in the compressed gas line (12), to the condenser (8). The refrigerant liquid which issues from the latter is taken up by the downstream installation liquid collector (32) and supercooled by contact with the atmosphere. The supercooled refrigerant liquid flows onwards to the expansion valve (10), where it is expanded to the vaporisation pressure (po) and injected into the vaporiser (9).

The vaporised refrigerant enters the SL operating chamber (3) as an intake gas stream ($\dot{V}o$) via the intake gas line (11). In this chamber, the liquids (refrigerant, residual oil or mixtures thereof) which have been entrained by the intake gas stream or have migrated from the liquid side are separated off efficiently and collected. Together with the issuing intake gas stream, these liquids are continuously drawn off, in an appropriately protected form, by the refrigeration compressor (7) via the intake gas line (11).

The degassed and cooled return oil stocked in the D operating chamber (2) passes, under a constant pressure difference (Δp), via an exit shut-off valve (5) and oil return line (17), and via an oil level regulator (14), into the crank case of the refrigeration compressor (7).

Figure 5 shows an illustrative embodiment of a three chamber, three function, UA3 separating apparatus with an operating chamber system (OS (1), D (2) and SL (3)) and interactions as described for Figure 4.

Figure 6 shows a modified embodiment of the three chamber UA3 separating apparatus where the different chambers are in different relative positions as compared with the construction of Figure 5.

Figure 7 shows the flow chart of a single-circuit refrigeration installation with one-stage compressor (7) and two chamber, two function, separating apparatus UA2, whose two operating chambers are based on the functions OS (1) and D (2). This accordingly results in the following interactions:

The refrigerant stream, generated by the refrigeration compressor (7), of the refrigeration circuit first enters the OS operating chamber (1) as a compressed gas stream ($\dot{V}$) via the compressed gas line (12). In the chamber (1), the compressor oil entrained by the compressed gas stream is separated off virtually completely and conveyed at the same rate as that at which it is separated from the gas in operation of the installation, into the D operating chamber (2) under compressed gas pressure (p). In this chamber, the compressed gas dissolved in the oil is expanded at a lower pressure ((po+Δp) <p) and led away to the intake gas line (11) via a degassing valve (6) and degassing line (24). The oil degassed and stocked in the D operating chamber (2) is cooled by the cooling action of the surrounding atmosphere ($t_{air} < t_D$).

The compressed gas stream ($\dot{V}$) passes from the OS operating chamber (1), via a downstream non-return valve (15) in the compressed gas line (12), to the condenser (8).

From the vaporiser (9), the vaporised refrigerant passes, as an intake gas stream ($\dot{V}o$), via the intake gas line (11) and installation liquid separator (16), into the refrigeration compressor (7).

A degassing line (24) leads from the degassing valve (6) to the return line from the vaporiser (9) to the liquid separator (16).

The degassed and cooled return oil stocked in the D operating chamber (2) passes, under a constant pressure difference (Δp), via an exit shut-off valve (5) and oil return line (17), and via an oil level regulator (14), into the crank case of the refrigeration compressor (7).

Figure 8 shows an illustrative embodiment of a two chamber, two function, UA2 separating apparatus as used in the installation of Figure 7.

The operating chamber 3, having the Venturi nozzle shown schematically in Figures 3, 5 and 6 is preferably constructed analogously to the liquid separator, with draw-off nozzle, described in German Offenlegungsschrift 2,602,582.

In addition to the various arrangements and positions of the operating chambers shown in the Figures, it is also possible to provide the following positions of the operating chambers, the positions and arrangements furthermore being capable of permutation: next to one another, above one another, concentrically above one another, or concentrically next to and above one another.

In addition to these various positions of the operating chambers, it is also possible to provide an arrangement which is star-shaped in plan view, in which the operating chambers can be located in the form of a rectangle or square or as sectors of the cross-section of a circle, so that in each case one operating chamber adjoins two neighbouring operating chambers.

CLAIMS

1. Liquid/gas separating apparatus for compression-type refrigeration installations which comprise at least two concentrically arranged chambers provided in a single apparatus, such chambers being constructed each to carry out a different one of the operating functions to separate oil from the compressed gas stream to degas the return oil and to separate liquid from the intake gas stream.

2. Apparatus according to claim 1, wherein at least three concentrically arranged chambers are provided, each being constructed to carry out an individual one of the three operating functions.

3. Apparatus according to claim 2, wherein four concentrically arranged chambers are provided, the fourth chamber being constructed to function to collect condensed refrigerant liquid.

4. Apparatus according to any preceding claim, wherein at least two of the chambers are in interacting connection with one another.

5. Apparatus according to claim 4, wherein the interacting connection is via a heat exchange surface

which separates the two chambers one from the other.

6. Apparatus according to any preceding claim, which has more than two of the chambers with these being so arranged that in each case one chamber adjoins not more than two neighbouring chambers *via* a sizable surface zone.

7. Apparatus according to any one of claims 1 to 5, which has at least four of the chambers with the chambers being so arranged that one of the chambers adjoins more than two of the others *via* a sizable surface zone.

8. Separating apparatus constructed and arranged to operate substantially as herein described with reference to and as illustrated in Figure 3, Figure 5, Figure 6 or Figure 8 of the accompanying drawings.

9. A compression-type refrigeration installation including separating apparatus as claimed in any preceding claim arranged for carrying out said functions during operation of the installation.

10. A compression-type refrigeration installation constructed and arranged to operate substantially as herein described with reference to and as illustrated in any one of the Figures of the accompanying drawings.

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